The Boll Weevil Complex in Arizona

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The Boll Weevil Complex in Arizona

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Since the discovery in 1912 of a boll weevil breeding in wild cotton (*Gossypium thurberi* Todaro = *Thurberia thespesioides* Gray) in the Santa Catalina Mountains near Tucson, Ariz., entomologists have been concerned about its potential as a pest of cultivated cotton. The weevil was described as a variety of the boll weevil by Pierce (*15*)[1] and named *Anthonomus grandis* var. *thurberiae* Pierce. It is commonly known as the thurberia weevil. The early concern of entomologists in Arizona led to extensive research between 1925 and 1941 by T. P. Cassidy and W. A. Stevenson (deceased) and H. C. Young and A. J. Chapman (retired) of the former U.S. Bureau of Entomology and Plant Quarantine. Since unfortunately the data and conclusions of these researchers were not published, pertinent data from their original manuscript are incorporated in this report.

From 1940 to 1960 the boll weevil was not a serious pest in the West except in the Presidio Valley of Texas, where it became an economic pest in 1953 (Robertson *16*). Incipient infestations detected near El Paso, Tex., in 1960, 1961, 1962, and 1963 and the detection of the boll weevil for the first time in California in 1965 and 1968 again raised the question of the potential of the boll weevil as an economic pest of cotton in the arid West. In the early 1960's, increased infestations in stubbed cotton in Arizona emphasized the importance of the problem and research was undertaken to determine the potential of the boll weevil in Arizona. Some of the research results have been reported by Bottger (*1*), Bottger and others (*2*), Fye (*4-7*), Fye and Bonham (*8*), Fye and Leggett (*9*), Fye and others (*10*, *11*), and Leggett and Fye (*14*).

The occurrence of a boll weevil in the northern part of the State of Sonora, Mexico, where cotton production has increased tremendously in recent years, complicated the problem. Increasing infesta-

[1] Italic numbers in parentheses refer to Literature Cited, p. 23.

tions in the Magdalena area of Sonora, within 30 miles of Nogales and within 140 miles of the cotton-producing area below Yuma, Ariz., posed a threat to cotton production in Arizona and California.

A major problem in dealing with the boll weevil in Arizona is the identification of the insect. Burke (*3*) stated the problem as follows:

> One of the most interesting questions dealing with the dispersal of western weevils involves the relationships of weevils from cultivated cotton with those on *Gossypium thurberi* in Arizona. Weevils on cultivated cotton in this area originated from either one or both of two possible sources. First, there is the definite possibility that they represent a northward extension of the coastal or lowland form presently attacking cotton in northern Sonora. There is an apparent gap between the most northerly infestations in Sonora and the southern infestations in Arizona, but the weevil could have easily flown or been accidentally imported across this narrow intervening area. Weevils from cultivated cotton in Arizona do not differ significantly in any morphological way from those on the cultivated cotton in Sonora; a few small differences which occur can be explained on the basis of normal geographic variation.
>
> The possibility must also be considered that weevils now attacking cultivated cotton in Arizona moved and adapted to this crop from thurberia plants. This does not necessarily mean that there has been, or presently is, mass movement of weevils between the two plants. Adaptation of small numbers could have taken place over a fairly long period of time with the result that the population on cultivated cotton finally reached the size where expansion was possible. It is well known that small numbers of weevils have been found in cultivated cotton in Arizona since about 1916, with sporadic outbreaks occurring in the early 1920's and larger infestations developing in recent years. The progeny of weevils collected originally from thurberia plants and subsequently reared on artificial media during the present study lost their thurberia weevil-like characters rapidly and as a result were no longer separable from weevils found on cultivated cotton in Arizona. Since this plasticity of phenotype has been demonstrated and since it is known that there is some movement of weevils from thurberia plants to cultivated cotton, the population on *G. thurberi* has to be considered as a possible source of infestations in cotton in Arizona. The discontinuous morphological variation between the weevils from some areas in Arizona may be directly related to their distance from established stands of thurberia plants and consequently, to the frequency and intensity of movement of weevils from thurberia plants into the population on cultivated cotton. The final answer to this question can only be obtained from field studies designed to determine the degree and method of movement of weevils from thurberia plants to cultivated cotton and also to determine the interaction of weevils in areas where infestations of the two hosts are in close proximity.

Burke (*3*) studied the taxonomy of the *Anthonomus grandis* Boheman complex and proposed to synonymize *Anthonomus grandis thurberiae* Pierce with *A. grandis* Boheman. However, he recognized the three forms within *A. grandis*—the thurberia boll weevil, the Mexican boll weevil, and the southeastern boll weevil.

Since the identification of the boll weevil in the West has not completely been resolved, the weevil found in cotton in northwestern Mexico, Arizona, and California is referred to in this report as the boll weevil complex (*Anthonomus grandis* Boheman). The weevil in cotton from Texas to the east coast is referred to as the boll weevil (*A. grandis* Boheman). The weevil that attacks the thurberia plant is referred to as the thurberia weevil (*A. grandis thurberiae* Pierce).

The Thurberia Weevil

Thurberia cotton (*Gossypium thurberi* Todaro) grows on rugged slopes and in washes at elevations between 3,500 and 5,500 feet in several mountain ranges in southeastern Arizona. The known distribution of thurberia was first reported by Hanson (*12*), but several additional cotton growths infested with the thurberia weevil were detected in surveys from 1925 to 1927. The known distribution is presented in figure 1.

Subsequent to the early research, appreciable effort was made to eradicate the thurberia cotton near cottonfields. Although this effort was extensive, discontinuing the eradication program resulted in thurberia cotton reestablishing itself throughout its original range and adjacent to cottonfields, particularly in the Santa Cruz River Valley.

Thurberia cotton is frequently associated with sotol (*Dasylirion wheeleri* Watson, mesquite (*Prosopis* spp.), catclaw (*Mimosa* spp.), scrub oak (*Quercus* spp.), yucca (*Yucca* spp.), and desert broom (*Baccharis* spp.). The most dense stands of thurberia occur on elevated areas along the sides or in the center of the large arroyos. It grows well at elevations as low as 2,000 feet, and at all elevations it is subject to winterkill when early freezing of the sap causes splitting of the bark away from the cambium at the base of the plant.

Winter rains are generally adequate to start growth of thurberia cotton in the spring. However, fruiting is not usually prolific on the early flush of growth. As the thunderstorms of July and August provide adequate moisture, the plants initiate additional growth, and fruiting begins early in September. The moisture from the storms frees the overwintering thurberia weevils by soaking the

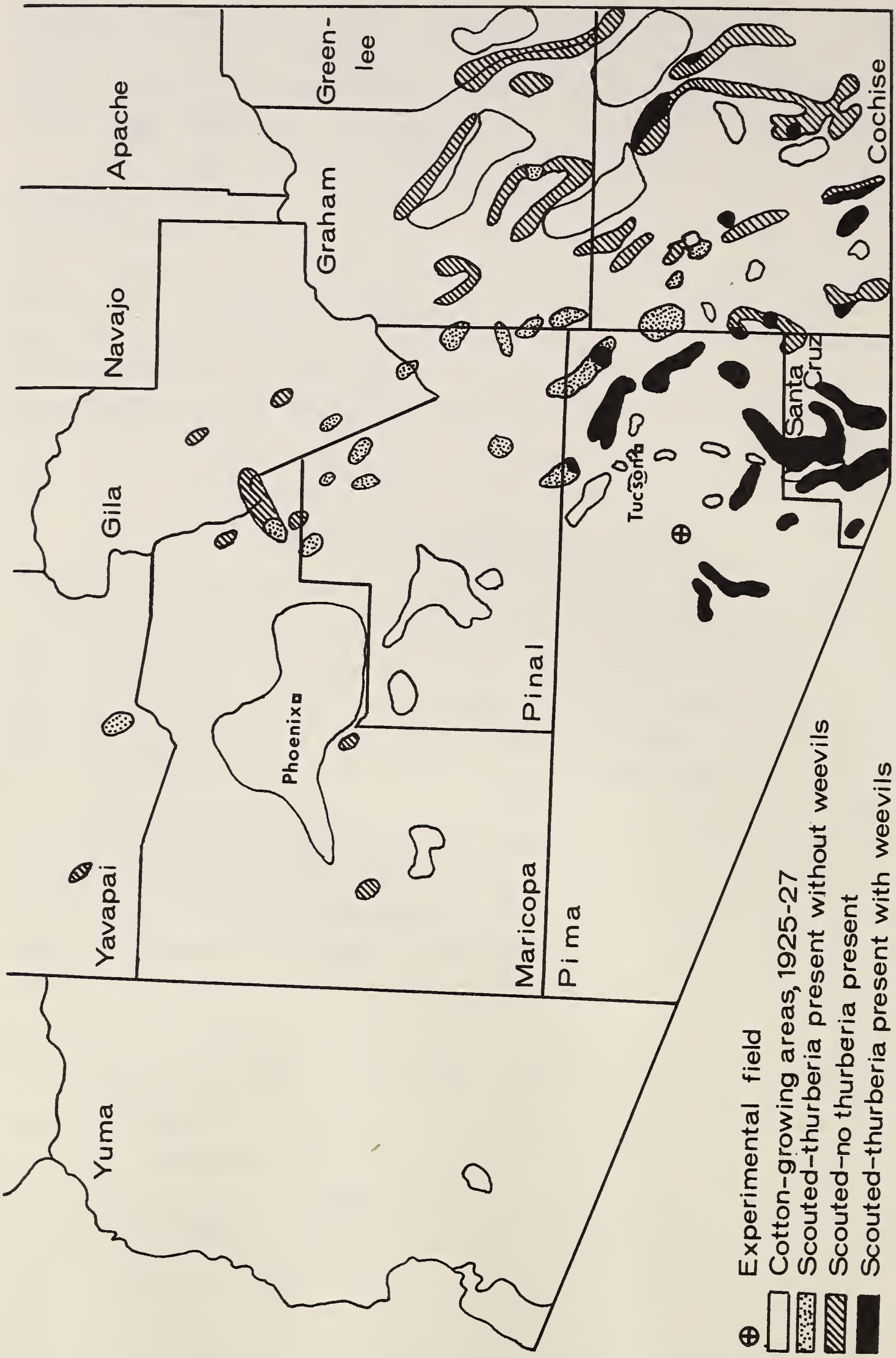

FIGURE 1.—Distribution of cultivated cotton, thurberia cotton, and the thurberia weevil in Arizona.

dried bolls containing the weevils, softening their cell walls, and permitting the weevils to cut their way from the cells.

Some of the weevils may be freed early by the winter rains, but generally they do not survive until the thurberia cotton is fruiting adequately to provide oviposition sites. However, Fye and Leggett (*9*) demonstrated that if adequate moisture is available, the weevils may survive though the survival rate is not equal to that of the weevils that remain in the cells in the thurberia bolls.

Fye (*7*) showed that release of the thurberia weevils did not coincide with the fruiting of the host thurberia and that the subsequent generation is the progeny of a small percentage of the females from the prior generation. Therefore, the weevils that survived hot, dry periods probably developed into a strain capable of existing under these unfavorable conditions.

A small generation reared in squares bridges the long period between the emergence of overwintering female weevils and the availability of thurberia bolls for oviposition. The square-reared generation was first noted by Cassidy and Young in 1926 in a collection of thurberia squares from the Coyote Mountains in Pima County. Fye (*7*) noted a few of these tiny square-reared weevils in 1965, but in 1966 he found them to be an important part of the population ovipositing in the bolls. However, the square-reared weevils are generally very small and weak with a relatively low fecundity compared with that of the parental overwintering generation. Fye (*4*) showed that overwintered females reared in thurberia bolls laid approximately 60 eggs per individual compared with 15 for those reared in squares.

Laboratory fecundity studies conducted by Fye (*4*) indicated that thurberia weevil females reared on cottonseed meal diet averaged 250 eggs per individual. The male and female thurberia weevils readily mated with weevils from cultivated cotton with no apparent effect on the fecundity of thurberia weevils or of weevils from cultivated cotton.

Fye (*7*) outlined the fate of punctured thurberia bolls for the 1965 and 1966 seasons in a colony of 100 thurberia plants in the Santa Rita Mountains. Many of the punctured bolls matured with little or no damage. Factors affecting boll loss and thus weevil mortality included normal physiological shed, grazing by cattle, removal by ground squirrels, and losses to unknown causes.

Parasitism in the 1965 and 1966 studies was negligible. The major parasites were *Bracon thurberiphagae* (Muesebeck), *Eurytoma tylodermatis* Ashmead, *Eupelmus* sp., and *Microdontomerus anthonomi* (Crawford). Mantids and *Apiomerus* sp. were observed as predators

of the weevils and several species of ants were noted preying on incapacitated weevils on the ground.

The annual thurberia weevil populations on the 100 thurberia plants in the Santa Rita Mountain foothills during May and December, respectively, were 2,365 and 192 in 1965, 44 and 1,922 in 1966, 844 and 1,338 in 1967, 262 and 957 in 1968, and 315 and 1,970 in 1969. The possibility of low populations resulting from high overwintering populations is evident. On the other hand, the high reproductive potential of the thurberia weevil is evident in the years in which large populations in December developed from small surviving overwintering populations.

The survival of the thurberia weevil in thurberia bolls retained on the plants was generally high. Collections in the spring of 1926, 1927, and 1928 showed survivals of 67, 89, and 95 percent, respectively. No weevils survived in infested bolls collected in the spring of 1926 and stored in an insectary until 1927. However, in a similar study in 1927 extending into 1928, 0.5 percent of the weevils were alive, indicating that they could survive at least 17 months in cells. Fye (*4*) showed that the average longevity of female weevils ovipositing in the laboratory was 187 days. Thus the longevity of overwintering weevils, both in the cell and after emergence, may be extended. Burke (*3*) described the thurberia weevil as being morphologically robust. Available physiological-ecological data indicate that the thurberia weevil is also physiologically robust.

The Boll Weevil Complex in Cultivated Cotton

Boll weevil complex infestations have occurred in cultivated cotton in Arizona for many years. In the early studies, infestations in the Santa Cruz River Valley were common, but only three were found in Pinal County and one in Graham County. The Santa Cruz River originates partly in Arizona and partly in Mexico near Nogales and flows north approximately 70 miles to Tucson, where it turns west and finally dissipates in the desert near Eloy. The river is dry most of the time, but it serves as an underground source of water. Cotton along this valley is grown entirely under irrigation from wells, but in the early days during flood seasons additional irrigation was provided with ditches from the Santa Cruz River.

In the 1920's the cultivated cotton in the Santa Cruz River Valley consisted of small fields near Tubac, Ariz., with larger producing areas near Sahuarita and Continental, where fields totaling approximately 3,000 acres were distributed along both sides of the river for several miles. The next cotton area of economic importance

was about 10 miles north of Tucson extending rather continuously to near Red Rock. From 9,000 to 12,000 acres of cotton were grown from Tubac to Red Rock each year from 1925 to 1941. Thurberia plants infested with weevils grew on mountain ranges that border the valley south of Tucson on both sides and for about 15 miles on mountain ranges on the northeast side of the valley north of Tucson.

In 1925 and 1926, surveys were made to locate weevil infestations in cotton grown commercially in the Santa Cruz Valley. These surveys were not quantitative, but incipient weevil infestations were found in several fields in the upper end of the valley.

Intensive inspections were made from 1927 to 1932 in the fall and early winter when weevils were found most easily. Representative fields were selected in all cotton-growing areas of the Santa Cruz Valley and all bolls showing signs of injury were examined at random. Thus incipient infestations that might have been overlooked by less selective methods were detected. Man-days expended and numbers of weevils found were as follows:

Year	*Man-days*	*Weevils (number)*
1927	180.9	1,385
1928	96.4	468
1929	136.1	1,058
1930	99.0	55
1931	18.2	498
1932	19.7	59
Total	550.3	3,523

The heaviest and most widely distributed infestation was in 1931. Unusual rainfall occurred in July, August, and September (34 days from July 1 to September 30). Though the precipitation was only 0.65 inch above normal, it occurred intermittently over a long period and favored weevil development. In the late fall of 1931 a few weevils were found in a cottonfield northwest of Red Rock. This field was located approximately 30 miles from thurberia plants infested with weevils and was the greatest distance that weevils had been found in cotton from a natural infestation in thurberia plants.

Researchers thought that this infestation probably came from infested thurberia bolls that were washed into the area by the unusual amount of flood water. However, Fye (*4*, *6*) demonstrated that water transport of the weevils in thurberia bolls was doubtful and that the major infestations in the 1960's occurred many miles from thurberia weevil infestations, which usually were the source of incipient infestations in cultivated cotton. These observations suggest that the large population in 1931 may have resulted from

a small, undetectable, omnipresent population of weevils and may not have been of thurberia origin.

In 1933, weevils were observed in connection with population studies of hemipterous insects, but the time spent and the number of weevils detected were not recorded. However, no weevils were found in the principal cotton-producing areas northwest of Tucson, but incipient infestations were seen throughout the upper Santa Cruz Valley. The heaviest infestation was near Tubac, where the valley is very narrow and weevil-infested thurberia plants grow on the surrounding mountains, often extending down to the cultivated areas. After a killing frost, practically all weevils were found in immature bolls. This infestation may have been produced from weevils that had been released from thurberia bolls.

Beginning in 1934 and continuing through 1941, boll weevil infestation records were kept in connection with other cotton insect studies. The infestations were recorded as percentages of bolls punctured, and inspections were made in representative fields throughout the valley at the end of the growing season. The infestation counts were made by examining 100 to 200 bolls in the corners and the center of each field, or a total of 500 to 1,000 bolls per field. All bolls on the plants were examined at each point until the desired number was inspected.

Less than 1 percent of the bolls inspected in the Santa Cruz Valley from 1934 to 1941 were damaged by boll weevils. Damaged bolls ranged from 0 in 1934 to 0.7 percent in 1941 with an average infestation of 0.2 percent for the 8-year period in 175 fields. This level of damage is not of economic importance in commercially grown cotton.

The boll weevil infestation records made in commercial cotton in the Santa Cruz Valley from 1925 to 1941 showed that weevils did not cause economic damage. Other records showed that the weevil had not spread to other cotton-producing areas of the State. The records made between 1923 and 1941 and those prior to 1925 after the weevil was discovered in 1912 indicated that the boll weevil would probably never be of economic importance in Arizona cotton so long as the then used cultural practices in producing the crop were continued.

In studies conducted by Fye (*5*), infestations in the Santa Cruz Valley were very low and did not reach levels to cause economic damage. In 1965, 1966, and 1967 studies, the major infestations occurred near Stanfield in Pinal County and near Horn in Yuma County, where stubbed cotton was grown. Furthermore, though the thurberia weevil had adequate time to move into all cotton-

growing areas in the intervening years, only a few infestations occurred late in the season.

At the same time cotton production increased in northern Sonora, Mexico. Bottger and others (*2*) described heavy boll weevil infestations in this area. Most of the boll weevils in northern Mexico spend the winter in cells in unpicked bolls in the field, but a small percentage of the population overwinters in ground trash as weevils do in the main boll weevil belt of the United States. Fye and others (*10*) found overwintering weevils in ground trash in areas of major infestation in Pinal and Yuma Counties.

In tests in the insectary Fye and Leggett (*9*) demonstrated that the thurberia weevil could also overwinter outside the cells in thurberia bolls. Thus the manner in which the weevils overwinter cannot be used to separate the two forms.

Results of the early studies indicated that thurberia weevils "readily" moved to cultivated cotton. Likewise, Bottger and others (*2*) indicated that their unpublished data showed that the thurberia weevil would "readily" move to the cultivated cotton. However, Fye (unpublished data), in an attempt to obtain specimens of the F_1 generation of thurberia weevils in cultivated cotton for the studies of Burke (*3*), found that the weevils taken directly from the thurberia bolls and caged on cultivated cotton plants failed to oviposit freely and extensive efforts produced very few weevils. The apparent reluctance of the thurberia weevils to move to the cultivated cotton readily indicated that the boll weevil from northern Mexico was probably responsible for the infestations in the 1960's.

Generally infestations of the boll weevil in Arizona have been relatively light during the growing season with the only economic damage occurring in the fall when bioclimatic dampers are released on boll weevil buildup.

Results of laboratory studies with weevils from cultivated cotton (Fye *4*) indicated that the lifespan of the female weevils averaged more than 100 days and as long as 294 days. Female weevils laid from 604 to 1,400 eggs per female. Under insectary and field-cage conditions the average longevity of the females ranged from 21 to 56 days and the fecundity of the females was reduced to 20 to 30 eggs per female. Thus the female weevils from cultivated cotton in Arizona have a high reproductive potential, which is not realized under the climatic extremes in the cottonfields (Fye and Bonham unpublished data).

Fye and others (*11*) in a study of the development period of four strains of weevils from cultivated cotton found that the development period ranged from 88 days at 15° C. to 17 days at 30°. The

development period was increased to 17.5 days when the weevils were reared at 35°. The deleterious effect of high temperatures partially explains the absence of boll weevil populations in Arizona in midsummer. Fye and Bonham (*8*) in their study of mortality of boll weevils on the soil surface while the immature weevils were developing in fallen squares also found that mortality occurred when the soil surface temperature exceeded 38°. Their data showed a direct relationship for mortality with a time-temperature index when the temperature exceeded 38°. The mortality of immature weevils due to high soil-surface temperatures further accounts for the small early-summer population of boll weevils in Arizona.

Where cotton bolls were examined in the early winter and spring of 1925, 1926, and 1927, records were kept of all weevil cells that showed evidence of parasitism, and several of the parasites were collected and reared. On an average 1.3 (range 0.8–2.2) percent of the weevils from bolls examined during the three seasons were parasitized. The percent parasitization was probably greater because some of the parasites had emerged before the examinations were made and some did not leave empty cocoons or other evidence of their presence. The parasites determined by A. B. Gahan were *Habrocytus piercei* Crawford, *Zatropis incertus* (Ashmead), *Microndontomerus anthonomi* (Crawford), *Bracon mellitor* Say, *Eupelmus cyaniceps amicus* Girault, and *Eurytoma* sp. Most have been known for years as parasites of the boll weevil, but they have never been considered a major control factor. There was no indication that naturally occurring parasites could be of any importance in controlling the boll weevil in Arizona.

Two predators were noted attacking the immature stages of the weevil in the experimental cottonfield. One was a very rare small beetle, *Phyllobaenus discoideus* (LeConte) ; its effect on the weevil populations was negligible. The other was a small fire ant, *Solenopsis geminata rufa* (Jerdon) (= var. *diabola* W. M. Wheeler), which is very common in southern Arizona though its nests are seldom found in large cultivated areas. The nests are usually located outside or near the edges of fields, and the workers go in all directions in search of food. The ants did not attack all the squares containing immature weevil stages around their nests when the squares were allowed to remain on the ground as they fell from the plant naturally, but if the squares were concentrated, as in cage studies, the ants attacked every square containing an immature weevil. Though this ant was apparently the most abundant natural enemy of the weevil, it is not likely to become an important control factor.

Hibernation Experiments

Hibernation studies were conducted in the winters of 1925–26 and 1926–27 to determine the number of weevils surviving the winter (1) as adults in cells in cotton bolls, (2) as freed weevils active in fall and placed in a hibernation site of sudangrass, and (3) as weevils freed from their cells in early January and placed in a hibernation site of sudangrass. Some of the bolls containing weevils were moistened in the spring and summer to study the effect of moisture on emergence. The number of weevils hibernating in cells and bolls was determined by examining the entire contents of the cage late in the summer or fall and adding the number of detected adults to the number emerged.

For the hibernation studies of 1925–26, a few standing cotton plants with bolls on each were placed in cages 1–3 on January 12, 1926. Cage 4 was installed on March 17, 1926. A total of 625 weevils were included in the four cages. Emergence began in March with the greatest number emerging in May. Four percent of the weevils emerged, and 29 percent were alive when examined from June 29 to July 27.

Cotton plants and bolls from the field were placed in cages 5–7 on March 17, 1926. The cages were flood irrigated on May 26, June 16, and July 17, and a fine spray was applied to cage 5 on July 17, 18, 19, and 20. Twenty-three percent of the 216 weevils emerged, and 2.3 percent were alive when examined from August 2 to 9. The greatest emergence was in May.

Weevils taken from their cells in cotton bolls were placed in cages 8 and 9 on January 11, 1926. Sudangrass was provided as hibernation material. A total of 595 weevils were installed and 278 emerged between March 1 and June 21.

Of 1,436 weevils included in all cages in the 1925–26 study, 539 (37.5 percent) survived.

For the hibernation studies of 1926–27, 243 weevils active in the field were placed in cages 10–13 in October and November 1926. Sudangrass was provided as hibernation material. Only three (1.2 percent) weevils emerged, one each on March 29, April 27, and May 18.

Weevils taken from cells in cotton bolls were placed in cages 14 and 15 on January 8, 1927. Sudangrass was furnished as a hibernation shelter. Of 546 weevils, 166 (30.4 percent) emerged between March 1 and May 22.

Cotton plants and bolls from the 1926 crop were placed in cages 16–20 on March 4, 1927, to determine the maximum hibernation

period of the weevil. Since the material was not examined in 1927, the percent survival could not be calculated.

Cotton plants and bolls from the 1926 crop were placed in cages 21 and 22 on March 4, 1927. The material was wetted with a fine spray on May 26, June 7 and 8, June 22 and 23, and July 22. The cages were moistened at 15-day intervals unless rain was sufficient. Rain on July 7 and 8, August 1 to 5, and August 21 was adequate and the moistening was omitted. Of 578 weevils installed, 131 (22.7 percent) emerged. The material in the cages was examined from October 27 to November 21 when the bolls had deteriorated and one live weevil was found. Unmoistened material in cage 23 was examined at about the same time. The survival was considerably greater in the cages with added moisture.

Cotton plants and bolls from the 1926 crop were placed in cages 23–26 on March 4, 1927. No moisture was added. Of 3,199 weevils installed in these cages, 4.7 percent emerged and 18.1 percent were alive in cells when the material was examined between June 11 and November 28, 1927. The survival was less in the cages examined late in the season, but the emergence of weevils was greater because of the extended period.

Some of the 1925 cotton bolls were kept through the 1927 season, and 2,785 bolls were examined from November 21 to 23, 1927. No live adults were found. No weevils emerged from the bolls in 1927 and the number that emerged in 1926 could not be definitely determined. However, six living weevils were found in one cage while the material was being examined from November 21 to 28, 1927. These weevils were alive for approximately 12 months after they entered hibernation and represented 0.7 percent of the adults installed. The results indicate that the boll weevil may be able to pass two winters.

Of the 4,566 weevils that hibernated in the 1926–27 season, 1,029 (22.5 percent) survived.

The study by Fye and others (*10*) of boll weevils released from cultivated cotton bolls into leafy trash showed that approximately 11 percent of the released weevils emerged after March 14. Their data also showed that only 3 percent of the weevils that had emerged before March 14 appeared again after March 21. They also found weevils in leafy trash in the desert areas surrounding infested cottonfields. However, most of the weevils hibernating in these sites either died or emerged from hibernation by the last part of March.

Stoner (*17*) indicated that the weevils could survive by feeding on *Sphaeralcea* spp. until cotton became available for food and for oviposition sites. Leggett and Fye (*14*) also demonstrated that boll

weevils removed from cotton bolls could survive the winter under temperature regimes simulating those at Stanfield, Ariz., when provided with adequate moisture. Therefore, it is evident from both the early as well as the later research that the boll weevil infesting cotton in Arizona can survive the winter, at least in small numbers, to infest the subsequent crop.

Cage Experiments

The development period for a few weevils in cotton squares and small bolls in 1926 and 1927 was determined in cages 4 by 4 by 4 feet and in small holding cages, which would not be entirely representative of the open field. The period recorded was often not the true development period because instead of emerging when adulthood was attained, many of the weevils remained in the cells for some days, particularly in the bolls, and during the last part of the season when very few emerged. In 1927, 15 weevils emerged from squares and small bolls punctured after September 1, but when all forms were examined on January 12, 1928, 11 living and four dead adults were found.

In 1926, the mean development period of two F_1 weevils was 24.5 days from cotton-reared stock in cotton squares and 20.1 days from thurberia-reared stock. One weevil did not emerge until 48 days after the egg was laid. In 1927, the mean development period was 21.7 days for 56 weevils from cotton-reared stock and 21.4 days for 55 weevils from thurberia-reared stock.

In 1926, 14 weevils from cotton-reared and thurberia-reared stock in small bolls averaged 36.6 and 41.2 days, respectively, for development. In 1927, 23 weevils from cotton-reared stock in small bolls averaged 27.7 days and 20 from thurberia-reared stock required 36.4 days. Seventeen F_2 weevils from cotton-reared stock emerged from small bolls, and on January 12, 1928, 12 living and six dead adults were found. Very few weevils emerged from bolls punctured after September 1. The development in bolls was very irregular and living larvae and pupae were found in January in bolls infested in late August. A living larva from an egg laid in a boll prior to November 1, 1925, was found in March 1926. Thus the weevil had remained in the larval stage for approximately 5 months.

The early data on the mean development period of the boll weevil are in accord with the development period described by Fye and others (*11*) for a fluctuating temperature of 25° C. The data were taken during the summer when the mean daily temperatures are considerably in excess of 25°. Therefore, it is apparent that the temperatures during the development period were in excess of the

upper threshold as suggested by Fye and others (*11*). The extended development periods in winter and the apparent absence of a true diapause (Fye and others *10*) explain the presence of living larvae during the winter.

Weevils that emerged each week in hibernation cages in 1926 were kept as groups without food or water as examinations were made at weekly intervals. Subsequent weekly records indicated only the maximum length of time the weevils lived without food because longevity of individuals was not determined.

During January 1926, 252 weevils were removed from cells in cotton bolls and placed in cages with sudangrass. They emerged from March 1 to June 21. Weekly examinations started after April 26 indicated 50 of the 56 weevils died within 7 days of emergence, but 10 weevils lived more than 21 days, three more than 48 days, and one between 76 and 83 days.

Seventy weevils hibernating in cells in cotton bolls in the winter of 1925–26 emerged between March 18 and June 17, 1926. Fifty-six died within 7 days, but two lived more than 21 days with the maximum between 35 and 41 days. One weevil that emerged on October 11 lived without food for 9 days and one that emerged on September 4 was fed on cotton squares and lived 38 days.

At intervals from March 31 to April 19, 1926, 135 weevils were removed from cells in thurberia bolls and kept without food or water. Six were dead on May 7, but the remainder lived more than 27 days with 78 living more than 43 days and the maximum longevity falling between 71 and 75 days. The greater longevity for the weevils removed from cells in thurberia bolls may have been affected by cooler temperatures early in the season before the other weevils emerged.

Weevils emerging in 1927 were kept under several conditions. Weevils removed from cells in cotton bolls in January 1927 were placed in cages in sudangrass. The mean longevity of 149 that emerged from March 1 to May 14, kept without food or water, ranged from 7.7 to 13.1 days. The maximum longevity for weevils emerging on March 1 and 2 was between 29 and 34 days. The weekly examination did not determine the exact day of death and the data permit estimates accurate to within 6 or 7 days. Four weevils emerged from May 9 to 12 and their mean longevity ranged from 17.8 to 23.3 days with a maximum between 25 and 31 days. Nine weevils emerged from May 9 to 22 and were fed on cotton seedlings for several weeks and then on squares. Their mean longevity ranged from 46.9 to 59.9 days with a maximum between 62 and 75 days.

The mean longevity of 119 weevils that hibernated in cells in

cotton bolls and emerged before May 12 was 6.1 to 11.7 days and the maximum was between 21 and 26 days when kept without food or water. Nineteen weevils emerging from May 9 to June 24 were fed on cotton seedlings. They had a mean longevity of 14.1 to 15.8 days with the maximum of more than 46 days. Between August 11 and September 1, 38 weevils emerged and were fed cotton squares. Their mean longevity ranged from 70.2 to 72.5 days with a maximum of more than 111 days. On November 17, 13 were alive and were placed in a hibernation cage, but none emerged in 1928.

Seven weevils removed from cells in cotton bolls of the 1926 crop between November 7 and 26, 1927, were kept in a glass tumbler. One lived until January 12, 1928, with a quiescent period of about 1 year and a longevity of 14 months.

The longevity of 58 weevils removed from thurberia bolls and given no food or water was 17 to 20 days with a maximum between 60 and 63 days; for 10 given water the longevity was 29 to 33 days with a maximum between 50 and 53 days; for nine fed on seedlings and squares the longevity was 68 days with a maximum of 158 days.

On March 29, 30, and 31, 1928, six weevils were removed from thurberia bolls of the 1926 crop. The weevils were given water and their average subsequent longevity was between 10 and 14 days with a maximum of 20 and 26 days and a total known longevity of at least 18 months.

The longevity of the various weevils under several conditions, as determined by the early workers, is in accord with the findings of Fye (*4*) with a general short longevity of weevils released from cotton bolls in the spring, but with a few long-lived individuals, which served as precursors for the subsequent generations. If the weevils are provided moisture, as noted by Fye and Leggett (*9*) and Leggett and Fye (*14*), the longevity of weevils from thurberia and from cultivated cotton is increased. Stoner (*17*) showed that the early emerging weevils will feed on *Sphaeralcea* spp. and undoubtedly its availability prolongs the life of the surviving weevils

Field Experiments

In an early study to determine whether the thurberia weevil could adapt to cotton, a field near Robles Junction, Ariz., was selected because it was relatively remote from other cultivated cotton. The elevation is approximately the same as that of the principal localities around Tucson where cotton is planted and mountain ranges intervene between all other cultivated cotton. The weevils used in the first experiments were collected from thurberia plants

in these mountains. The ranch where the experimental plot was located and the adjacent ranch now produce cotton commercially.

The 1-acre field was located in the desert. The land was prepared in the spring, planted to Acala cotton, cultivated, and irrigated when necessary. Because of the extreme desert condition and difficulties with the irrigation pump, the cotton did not grow virgorously the first season; however, the plants grew normally in other seasons.

In the spring of 1925 and 1926, the weevil-infested bolls for the experiments were collected from *Gossypium thurberi* at intervals in April and May from several mountain ranges near the experimental field.

The bolls were kept in paper bags or glass jars in a dry place until needed. In 1925, four lots of bolls were placed on moist sand to force emergence of the weevils. Sufficient numbers for the experiment emerged on June 8, 16, and 23, and July 17. In 1926, the weevils were removed from the thurberia bolls and introduced into the field as needed.

The field was rectangular and the weevils in pans or tumblers containing moist sand were released in its corners and center. Only weevils reared from cultivated cotton in the open-field studies were to be used after 1925; however, large numbers of cotton-reared weevils were needed in other studies and it was necessary to supplement them with thurberia-reared weevils in 1926. Only cotton-reared weevils were used in 1927.

In 1925, 733 thurberia weevils were released from June 8 to September 1 (table 1). In 1926, 222 cotton-reared weevils from the 1925 crop and 679 weevils from thurberia bolls were released in the field from June 24 to September 1 with only 214 weevils released before August 1. Six hundred and eight weevils from cultivated cotton were introduced from June 11 to August 9 in 1927.

Infestation counts were started as soon as sufficient squares were present; however, the first weevil releases were made before the plants had begun to square. Plant examinations were made after the first release each season and continued until squaring started. The weevils fed readily on the terminal buds of the plants, but after the squares began to form, they transferred to the squares and oviposition began.

The infestation counts were made by selecting four representative points near the corners and one or two near the center of the field and examining 200 squares or bolls at each point. Every square or boll on a plant was examined, and plants were taken successively in the row until the desired number of squares or bolls had been examined at each point. Both egg and feeding punctures in the

TABLE 1.—*Weevil infestations in squares and bolls in experimental cottonfield, 1925–36*

Date released	Weevils released	Maximum infestation in— Squares	Bolls
	Number	*Percent*	*Percent*
June 8–Sept. 1, 1925	733	12.4	8.4
June 24–Sept. 1, 1926	901	2.3	17.7
June 11–Aug. 9, 1927	608	7.2	27.4
June 18–Aug. 28, 1928	320	2.5	17.4
June 18–Aug. 14, 1929	393	12.0	29.2
July 8–31, 1930	230	11.4	28.6
June 29–July 20, 1931	200	8.9	25.7
July 5–19, 1932	200	5.1	20.0
July 11–25, 1933	200	11.8	17.2
July 3–Aug. 24, 1934	163	2.1	9.6
July 8–Sept. 19, 1935	72	2.0	4.5
July 9–Aug. 13, 1936	48	1.0	2.5

squares were recorded, but only egg punctures were recorded for the boll infestation. A feeding puncture may not damage a boll, whereas it often causes the square to shed. Frequently it is impossible to distinguish weevil feeding punctures on bolls from other injuries.

The square infestation records were started on June 23, 24, and 30 and were concluded on August 20, 25, and 30 in 1925, 1926, and 1927, respectively. Inspections were made at weekly intervals between the dates indicated. The infestations ranged from 0.4 to 12.4 percent in 1925, from 0.1 to 2.3 percent in 1926, and from 0.8 to 7.2 percent in 1927.

The first boll infestation counts were made on July 13, 24, and 26 and were continued at weekly intervals until August 27, September 24, and 27 in 1925, 1926, and 1927, respectively. The percent boll infestations ranged from 2.6 to 8.4, 0.2 to 17.7, and 1.3 to 27.4 in 1925, 1926, and 1927, respectively. Thus the maximum infestations in 1926 and 1927 were 2.0 and 3.5 times as great as the maximum in 1925.

Concurrently with the infestation counts, the squares and bolls were counted to determine the weevil's preference for squares or bolls. The fruit and weevil damage records indicated that the boll weevil had a slight preference for bolls for egg deposition, although squares were preferred at certain times. The reasons for the inconsistencies in the preferences for the two oviposition sites are not evident; however, Fye and Bonham's (unpublished data) data suggested that the changing preference was associated with the fruiting cycle of the cotton plants.

The cotton was allowed to grow to maturity subject to the attack of the released weevils and their progeny. The weevils were undis-

turbed until after a killing frost, when examinations were started to determine the number of live or dead weevils, their development stage, the number of empty cells, and final infestation data. In the spring, when the weather began to warm, a similar examination was made to determine the number of weevils that had survived the winter.

In December 1925, 25,673 bolls were examined. All bolls on the plants and on the ground were collected. Weevil forms or cells were found in 6.8 percent of the bolls and an additional 2.8 percent were egg punctured. Of 1,550 weevil forms, 71.9 percent were alive.

In March 1926, the cotton grown in 1925 was examined. Of 19,180 bolls examined, 991 weevil stages were found and 669 weevils (67.5 percent) were alive. Of 1,553 cells, 362 (23.3 percent) were empty. Thus very few weevils emerged in January and February, and less than 5 percent of the stages died.

In the early winter of 1926, of the 12,085 bolls examined, 6.6 percent contained weevil forms and 1.9 percent had egg punctures. Seventy-one percent of the 781 weevil forms were alive.

In early March 1927, cotton grown in 1926 was examined. A total of 12,000 bolls were examined and 643 weevil forms were found. Of this number, 408 (63.5 percent) were alive. Of 827 cells, 184 (22.2 percent) were empty. As in the previous winter, very few, if any, weevils emerged during January and February and less than 8 percent died.

The midwinter examination in 1927 consisted of 10,064 bolls, of which 7.9 percent contained weevil forms or cells and 4.1 percent were egg punctured. Of 694 weevil stages, 65.9 percent were alive.

From February 27 to March 2, 1928, cotton grown in 1927 was examined. A total of 10,153 bolls were examined and 723 weevil forms were found. Of this number, 435 (60.2 percent) were alive. Of 974 cells, 251 (25.8 percent) were empty. Few weevils emerged in January and February and less than 6 percent died.

In the three seasons 69.6 percent of the weevils were alive at the beginning of the hibernating period and 63.7 percent were alive in the spring. Thus about 91 percent of the weevils hibernating in the cotton bolls survived the winter.

The percentage of egg-punctured bolls that produced weevil cells was also obtained in these studies. Several bolls marked during the season with tags bearing the dates of puncture were examined in January. In the three seasons 610 bolls punctured from August to October were examined and 46.4 percent of them contained weevil cells. Thus at least 53.6 percent of the eggs deposited in the bolls were destroyed by proliferation, failure of the newly hatched larvae

to become established, high temperatures, or other factors. More of the eggs produced weevil cells and stages when deposited in small bolls than in the larger bolls, which were nearer maturity. Thus a high percentage of the eggs may be expected to produce weevils when most of the punctured bolls are young.

Transfer of Weevils From Thurberia Plants to Cotton

Infested cottonfields located 5 or more miles from infested thurberia plants usually did not become reinfested in successive years, but cottonfields adjacent to infested thurberia plants were infested every year. However, the infestations did not develop until late in the season. Apparently the weevils were not carried over from one year to the next in cottonfields, and the infestations were initiated by weevils from thurberia plants. Since infestations in commercially grown cotton were usually very light, a small isolated field of cotton surrounded by infested thurberia plants and favoring weevil transfer to cotton was grown at Fresnal Wells in the foothills of the Baboquivari Mountains at an elevation of 3,300 feet, approximately 36 miles southwest of Tucson.

In April 1930, a 1/4-acre field was prepared in the usual manner for growing cotton under irrigated conditions and planted to an American-Egyptian variety. The field was surrounded on all sides by weevil-infested thurberia plants with the nearest plants 54 feet away. Infestation records were begun in the field as soon as squares appeared on the plants in sufficient numbers and were continued at weekly intervals throughout the season. The experiment was conducted each year from 1930 to 1934, inclusive.

The maximum weevil infestation in bolls was 33.8, 31, 44, 39.8, and 17.7 with a mean of 33.3 percent, and the mean infestation was 28.7, 5.7, 21.3, 8.5, and 0.67 with a mean of 13 percent in 1930, 1931, 1932, 1933, and 1934, respectively. Infestations in bolls did not develop until late August. The only infestation in squares was detected on August 13, 1931, when a 0.2-percent infestation was attributed to favorable conditions for weevil development resulting from the heavy rainfall.

The cotton plants in the field were allowed to stand until late winter when they were destroyed and many infested bolls shattered onto the ground. The bolls were plowed under and the field was irrigated in early March in preparation for planting the following crop. Infestations did not appear in the field until late August after weevil emergence occurred from thurberia bolls, indicating

that weevils in fields plowed and irrigated for the following crop were forced out of hibernation early and died before cotton squares and bolls were available for oviposition.

Adaptation of Thurberia Weevil to Cotton

In connection with studies made in a 1-acre field of experimental cotton, the thurberia weevil was to be reared continuously in domestic cotton for 10 years and its infestations were to be compared with natural infestations in commercial cotton in the Santa Cruz Valley. Results of earlier studies indicated the weevils could not maintain themselves in cotton under natural conditions because they hibernated in pupal cells and were not freed until sufficient rain occurred to release them. Therefore, weevils were introduced in the field when squares and bolls were most vulnerable to their attacks.

Because initial infestations of less than 200 overwintered boll weevils per acre were known to cause serious damage in the Southeast in years when conditions were favorable, the number of thurberia-reared weevils released in the 1-acre field from 1925 to 1930 appeared excessive (table 1). Thereafter the number to be introduced each year was reduced to 200 per acre. Two hundred weevils were introduced in the field from 1931 through 1933, but the number was necessarily reduced below that level in 1934, 1935, and 1936.

The date of the weevil introduction, the number of weevils introduced, and the maximum square and boll infestations are shown in table 1. The boll infestation in 1925 was 8.4 compared with 2.5 percent in 1936. The square infestation varied from 12.4 percent in 1925, when thurberia-reared weevils were used, to 1 percent in 1936, when the weevils reared in cotton for 10 years were used.

The infestations produced from cotton-reared thurberia weevils indicated that the weevil did not adapt itself to cotton during the 10 years. At the end of each season all the cotton plants were cut and placed in large cages to provide weevils the following year. In the 12 years no infestations were found before weevil releases were made, indicating that no weevils survived naturally until squares and bolls were available for feeding and oviposition.

In 1937, cotton was grown in the field, but no weevils were released. Weekly square and boll infestations recorded throughout the growing season gave negative results. In December every boll in the field that showed signs of injury was examined and nine small weevil larvae were found. These larvae may have been the progeny of one or two female weevils that escaped from infested thurberia bolls stored in the adjacent insectary.

Control of Boll Weevil Complex With Cultural Methods

Results of the hibernation studies showed that many weevils hibernate in their pupal cells and are dependent on moisture for emergence in the subsequent season. It was also demonstrated that the weevils apparently transferred to cotton grown near infested thurberia plants. However, weevils produced in cotton did not carry over from one year to the next when the fields were cleaned, cultivated, and irrigated in late winter or early spring as they did in normal farming practices. This result indicated that populations in most infested cottonfields could be suppressed for nearly the full season with cultural practices.

It was known that live weevils were buried in their pupal cells in cotton bolls by plowing, but it was not known whether all the weevils were killed by the cultural method or if some survived and were forced out of hibernation early in the season and died before cotton fruit was available for oviposition.

In the winter of 1933 weevil-infested cotton bolls were collected, and on February 5 a sample of 100 bolls was examined to determine the percentage of bolls harboring live weevils. Eight hundred and eighty-two intact bolls containing live weevils were spread on the ground and plowed under with a 14-inch moldboard plow. The area was covered with a cage, 8 by 12 by 6 feet, surrounded by an irrigation border, and flood irrigated as in normal farming practices. On March 1 the area was irrigated again and then at monthly intervals throughout the season. Beginning on March 1 daily examinations were made for weevil emergence and the weevils that emerged were collected and placed in the insectary for longevity studies. The test was repeated each season from 1934 through 1937. The emergence records are shown in table 2.

Table 2.—*Boll weevil emergence from cotton bolls plowed under and irrigated, 1934–37*

Date plowed	Bolls plowed under	Weevil emergence in—			Total
		March	April	May	
	Number	*Number*	*Number*	*Number*	*Percent*
Feb. 5, 1934	882	31	10	1	4.6
Feb. 5, 1935	777	12	12	1	3.2
Feb. 6, 1936	187	3	2	0	2.7
Feb. 5, 1937	957	28	14	0	4.4
Total or average	2,803	74	38	2	4.0

The data in table 2 show that all weevils were not killed by the plowing. From 2.7 to 4.6 percent of the weevils emerged in March and April (except one weevil emerged in May 1934 and one in May 1935). Longevity studies showed that the mean life of the emerged weevils was from 9.1 to 12.5 days when given no sustenance and the maximum longevity varied from 3 to 21.7 days. These data suggest that weevils emerging in properly cleaned, cultivated, and irrigated crop fields in late winter or early spring may die before cotton fruit is available.

Fye (*5*) confirmed the view of the early research workers by noting that the proper sanitation measures applied to cotton crop residues would materially reduce the boll weevil infestation in the subsequent year. Fye and others (*10*) also noted that plowing under the crop residue to the depth of 1 foot would adequately control the overwintering boll weevils. The efficiency of these cultural controls has been well demonstrated since increased populations of the pink bollworm (*Pectinophora gossypiella* (Saunders)) have necessitated an intensified sanitation program for cotton crop residues in Arizona. The improved sanitation measures, including the ban on growing stubbed cotton, have resulted in the virtual absence of the boll weevil in cotton in Arizona and no economic damage has been reported.

Discussion and Conclusions

The interpretation of data obtained in Arizona is complicated by the presence of two slightly dissimilar populations of boll weevils. The early work was directed toward associating the thurberia weevil with cultivated cotton in Arizona and is particularly difficult to interpret because the possible presence of a second population of weevils was not considered.

In the choice of "remote" sites in which to study the movement of the thurberia weevil, the early workers inadvertently selected sites in which large-scale thermal upheavals occur. The areas of Fresnal Wells and Robles Junction are in the heart of an area now used by Tucson glider pilots as a soaring area. Consultations with these pilots indicate that the thermal activity is extremely intense with a marked differential in the updrafts and downdrafts at the mutual edges of the desert and cultivated areas.

Johnston (*13*) noted that the first commercial plantings in Sonora in the 1920's were attacked by weevils, and Fye (*6*) noted that the thermals in Arizona and northern Sonora were of sufficient intensity to elevate and transport boll weevils over long distances. In addition, the fields on the ranch where the original experimental

field was located have been consistently infested in past years (Fye *5*). Therefore, since potentially immigrating weevils from northern Sonora were not considered, the interpretation of the early data may not be entirely accurate.

The data from the two eras (1920–30 and 1960), however, indicate a common conclusion. They show that the thurberia weevil may be the source of infestations, probably minor, in cultivated cotton in areas where thurberia grows adjacent to cultivated cotton. However, the history of relatively minor boll weevil infestations in the Santa Cruz Valley over the years suggests that the thurberia weevil is not a major menace to cultivated cotton. However, the boll weevil's presence in northern Mexico, which was apparently responsible for heavy infestations in recent years, may be a threat to the top crop produced in late fall in Arizona.

Both the thurberia weevil and the boll weevil complex can be controlled with proper sanitation measures applied to the crop residues, particularly preventing the growing of stubbed cotton. Thus although bioclimatic controls are generally adequate to minimize the economic damage to cotton by boll weevils in Arizona, the grower may further minimize the damage with proper cultural practices.

Literature Cited

(1) Bottger, G. T.
1965. STUB COTTON PROVIDES HAVEN FOR WESTERN BOLL WEEVIL. Prog. Agr. in Ariz. 17 (1) : 12–13.

(2) ——— Cross, W. H., Gunderson, W. E., and Wene, G. P.
1964. RECENT RESEARCH ON THE BOLL WEEVIL IN NORTHERN SONORA, MEXICO, AND THE THURBERIA WEEVIL IN ARIZONA. Jour. Econ. Ent. 57: 286–290.

(3) Burke, H. R.
1968. GEOGRAPHIC VARIATION AND TAXONOMY OF ANTHONOMUS GRANDIS BOHEMAN. Tex. A & M Univ. Agr. Expt. Sta. Dept. Ent. Tech. Rpt. June 1968, 152 pp.

(4) Fye, R. E.
1962. LONGEVITY AND FECUNDITY OF THE BOLL WEEVIL COMPLEX IN ARIZONA. Jour. Econ. Ent. 62: 1408–1412.

(5) ———
1968. POPULATIONS OF BOLL WEEVIL IN SELECTED FIELDS IN ARIZONA IN 1965 AND 1966. Jour. Econ. Ent. 61: 377–380.

(6) ———
1968. SPREAD OF THE BOLL WEEVIL BY DRAINAGE WATER AND AIR CURRENTS. Jour. Econ. Ent. 61: 1418–1424.

(7) ———
1968. THE THURBERIA WEEVIL IN ARIZONA. Jour. Econ. Ent. 61: 1264–1268.

(8) Fye, R. E., and Bonham, C. D.
1970. SUMMER SOIL SURFACE TEMPERATURES AND THEIR EFFECT ON BOLL WEEVIL SURVIVAL IN FALLEN SQUARES. Jour. Econ. Ent. 63: 1599–1602.

(9) ——— and Leggett, J. E.
1969. WINTER SURVIVAL IN ARIZONA OF THURBERIA WEEVILS RELEASED FROM THURBERIA BOLLS. Jour. Econ. Ent. 62: 467–470.

(10) ——— Leggett, J. E., and Bonham, C. D.
1970. WINTER SURVIVAL OF THE BOLL WEEVIL COMPLEX IN ARIZONA. Jour. Econ. Ent. 63: 1071–1074.

(11) ——— Patana, R., and McAda, W. C.
1969. DEVELOPMENT PERIODS FOR BOLL WEEVILS REARED AT SEVERAL CONSTANT AND FLUCTUATING TEMPERATURES. Jour. Econ. Ent. 62: 1402–1405.

(12) Hanson, H. C.
1923. DISTRIBUTION OF ARIZONA WILD COTTON. Ariz. Agr. Expt. Sta. Tech. Bul. 3, 59 pp.

(13) Johnston, H. G.
1963. STATUS OF THE WESTERN BOLL WEEVIL—CURRENT PROGRAMS AND OUTLOOK. Cotton Gin and Oil Mill Press Mar. 16, 1963, pp. 63–66.

(14) Leggett, J. E., and Fye, R. E.
1969. THE ROLE OF MOISTURE IN THE WINTER SURVIVAL OF THE BOLL WEEVIL COMPLEX IN ARIZONA. Jour. Econ. Ent. 62: 147–149.

(15) Pierce, W. D.
1913. THE OCCURRENCE OF A COTTON BOLL WEEVIL IN ARIZONA. Jour. Agr. Res. 1: 89–98.

(16) Robertson, O. T.
1957. OCCURRENCE OF THE BOLL WEEVIL IN THE BIG BEND OF TEXAS. Jour. Econ. Ent. 50: 102.

(17) Stoner, A.
1968. SPHAERALCEA SPP. AS HOSTS OF THE BOLL WEEVIL IN ARIZONA. Jour. Econ. Ent. 61: 1100–1102.

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